APPENDIX D

EVALUATION OF RISKS FROM DEGRADATES, POLYOXYETHYLENE-AMINE (POEA) AND R-11, AND ENDOCRINE DISRUPTING CHEMICALS

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Introduction

This appendix was prepared in response to public comments on the Draft PEIS. Specifically, this appendix addresses three concerns raised by the public about the human health and ecological risk assessments prepared for the PEIS:

- Some surfactants may be more toxic to aquatic receptors than the active ingredient in an herbicide. Using polyoxyethyleneamine (POEA) as an example, what are the potential impacts of surfactants in Roundup Original® and Honcho® applied with glyphosate and R-11?

- The risk assessments only address the potential impacts of the active ingredients, what about the toxicity of degradates?

- The risk assessments did not identify endocrine disruption as a toxic endpoint. Are any of the herbicides considered to be endocrine disrupting chemicals?

Potential Ecological Impacts of the Surfactant Polyoxyethyleneamine (POEA) and R-11

The glyphosate ecological risk assessment (ERA) conducted by the U.S. Department of Agriculture Forest Service (Forest Service; Syracuse Environmental Research Associates [SERA] 2003) identified the potential for ecological risks associated with the use of a surfactant included in some glyphosate formulations. This surfactant, polyoxyethyleneamine (POEA), is an ethoxylated tallow amine on the U.S. Environmental Protection Agency (USEPA) List 3 of Inert Ingredients of Pesticides (Inerts of Unknown Toxicity). POEA by itself is much more toxic to aquatic organisms than glyphosate. Therefore, there may be greater risk associated with applications of POEA-containing glyphosate formulations than with applications of non-POEA-containing glyphosate near aquatic systems.

For this assessment, concentrations of POEA in a hypothetical stream and pond resulting from an application of Roundup Original® and/or Honcho® were estimated and compared to toxicological values for fish, aquatic invertebrates, and amphibians.

Toxicity data for POEA were reviewed, and median lethal concentration (LC_{50}) values were identified for four groups of aquatic receptors: threatened, endangered, and sensitive (TES) fish (represented by the rainbow trout, *Oncorhynchus mykiss*); non-TES fish (represented by the bluegill and fathead minnow, *Lepomis macrochirus* and *Pimephales promelas*, respectively); non-TES invertebrates (represented by the water flea, *Daphnia pulex*); and amphibians (represented by the African clawed frog, *Xenopus laevis*). Selected toxicity values for POEA are presented in Table D-1.

The Forest Service glyphosate ERA (SERA 2003) and the herbicide labels for Honcho® and Roundup Original® (both of which are Monsanto products that may be used by the BLM) were reviewed to identify application rates and percent surfactant present in the applied products. The ERA for glyphosate considered typical and maximum glyphosate application rates of 2 and 7 pounds (lbs) acid equivalent (a.e.)/acre (equivalent to 2.67 to 9.33 lbs active ingredient (a.i.)/acre), respectively (SERA 2003). According to the Honcho® and Roundup Original® labels, each product contains 41% glyphosate and 8% surfactant by weight, conservatively assumed to be 100% POEA. Therefore, for modeling purposes, the typical and maximum application rates for POEA were calculated as 0.521 and 1.82 lbs/acre, respectively (41/8 or 5.125 times less POEA per acre than glyphosate). In addition, investigators have found POEA to be acutely toxic to amphibians (Diamond and Durkin 1977; Howe et al. 2004; Relyea 2005).

AgDrift results for the ERAs for herbicides evaluated by the BLM (see Appendix C of the PEIS) were reviewed to select a conservative set of results that could be used to estimate the POEA concentrations deposited at varying distances from an application site. The percent active ingredient remaining at each of the evaluated distances (0, 25, 100, and 900 feet for ground applications, and 0, 100, 300, and 900 feet for aerial applications) was determined, and the most conservative result from each scenario (i.e., the maximum amount of active ingredient remaining at 900 feet) was selected for use in the POEA evaluation. The selected results represented ground applications with a high boom, and aerial applications over non-forested areas. Table D-2 presents a summary of the most conservative AgDrift model results, as well as average model results.

The typical and maximum POEA application rates (0.521 and 1.82 lbs/acre, respectively) were modeled for the hypothetical pond and stream (using the water body volumes and assuming an instantaneous concentration) and multiplied by the maximum percent herbicide remaining at each distance (based on the most conservative AgDrift modeling results presented in Table D-2). These conservative pond and stream concentrations were then compared against the toxicity data to generate risk quotients (RQs; Table D-3).

The RQs were compared to the levels of concern (LOCs) from the BLM ERAs to identify scenarios that could indicate the potential for risk to aquatic receptors from POEA. RQs for stream scenarios were higher than RQs for pond scenarios. The majority of the RQs were below the most conservative LOC of 0.05 (acute endangered species). The majority of the RQs greater than 0.05 were generated at the point of application (0 feet). A distance of 0 feet from the point of application is a highly conservative scenario in that it essentially assumes a direct application to the water body with no dilution or drift (i.e., drift distance equals 0 feet). This scenario is highly unlikely under BLM application practices. The stream and pond RQs for TES fish and the stream RQ for non-TES fish exposed to POEA 100 feet from an aerial application at the maximum rate were also greater than the most conservative LOC considered in the ERAs (0.05; acute endangered species). This indicates that a buffer zone of greater than 100 feet is necessary for aerial applications of POEA at the maximum rate in an area containing TES fish species.

As discussed under Mitigation in Chapter 2 of the Final PEIS, the BLM would avoid using any formulations with POEA, or seek to use the formulation with the lowest amount of POEA available, to reduce risks to aquatic organisms. It is also unlikely that the BLM would apply glyphosate herbicides containing POEA in an area known to contain endangered aquatic species, so comparisons to the endangered species LOC may be overly conservative. A comparison to the acute high risk LOC of 0.5 may be more appropriate. The only RQs greater than the LOC of 0.5 are generated in the stream at the point of application (0 feet) using the maximum application rate. As stated previously, this scenario is highly unlikely and assumes zero dilution and no drift (i.e., essentially direct application). However, even under these conditions the RQs are quite low: 1.57 for TES fish and 1.02 for non-TES fish. RQs for invertebrates and amphibians are less than 0.5 under all scenarios.

This assessment indicates that even under conservative conditions (scenarios with the most conservative amount of drift, and herbicide applications at the maximum rate) the potential risks to aquatic receptors from POEA are minimal under BLM application scenarios. However, because of lack of physical chemical property information, POEA was not modeled for leaching properties and runoff to water bodies and aquatic receptors. Therefore, there is some uncertainty associated with that pathway.

The adjuvant R-11 is a nonylphenol ethoxylate that is acutely toxic to aquatic life, and is suspected to be an endocrine-disrupting chemical (Bakke 2003, Stark and Walthall 2003). The BLM has decided to suspend the use of R-11 in its herbicide applications.

Degradates

While it is preferable to estimate not just the risks from the active ingredient of an herbicide, but also the cumulative risks of all chemicals included in the applied formulation (i.e., inert ingredients, adjuvants,

TABLE D-1
Selected Toxicity Values for Polyoxyethyleneamine

Common Name	Scientific Name	Endpoint	Exposure Duration (hours)	Concentration (mg/L)[1]	Source
Rainbow trout, Donaldson trout	*Oncorhynchus mykiss*	LC_{50}	96	0.68	Mayer and Ellersieck (1986)
Bluegill	*Lepomis macrochirus*	LC_{50}	96	1	Mayer and Ellersieck (1986)
Fathead minnow	*Pimephales promelas*	LC_{50}	96	1	Folmar et al. (1979)
Water flea	*Daphnia pulex*	LC_{50}	48	2.35	Moore et al. (1987)
African clawed frog	*Xenopus laevis*	LC_{50}	96	6.8	Perkins et al. (2000)

[1] mg/L = Milligrams per liter.

TABLE D-2
Review of AgDrift Results

Distance From Application (feet)	Percent of Active Ingredient Remaining in Pond and Stream at Various Distances [1]			
	Most conservative model results [2]		Average model results	
Ground Application	Stream	Pond	Stream	Pond
0	100	100	100	100
25	1.88	2.67	1.87	1.08
100	0.53	1.4	0.5	0.57
900	0.05	0.22	0.04	0.09
Aerial Application	Stream	Pond	Stream	Pond
0	100	100	100	100
100	7.75	5.4	7.18	4.92
300	2.84	2.53	2.41	2.17
900	1.23	1.17	1.06	1.02

[1] Based on a review of AgDrift results for herbicides evaluated in the ERAs in Appendix C of the PEIS.
[2] The most conservative model results (i.e., maximum herbicide concentrations, as a percent of applied rate, from AgDrift model) were selected to estimate POEA concentrations in ponds and streams.

TABLE D-3
Polyoxyethyleneamine (POEA) Risk Quotients (RQs) for Aquatic Exposure

Application Method and Rate	Distance From Application (feet)	Estimated POEA Concentrations (mg/L)		TES Fish [1, 2]		Non-TES Fish [3]		Non-TES Invertebrates [4]		Amphibians [5]	
		Stream	Pond	Stream RQ	Pond RQ	Stream RQ	Pond RQ	Stream RQ	Pond RQ	Stream RQ	Pond RQ
Ground Application (high boom) Typical Rate	0	2.92E-01[6]	5.84E-02	**4.49E-01**	**8.98E-02**	**2.92E-01**	**5.84E-02**	**1.24E-01**	2.49E-02	4.29E-02	8.59E-03
	25	5.49E-03	1.56E-03	8.45E-03	2.40E-03	5.49E-03	1.56E-03	2.34E-03	6.64E-04	8.07E-04	2.29E-04
	100	1.55E-03	8.18E-04	2.38E-03	1.26E-03	1.55E-03	8.18E-04	6.60E-04	3.48E-04	2.28E-04	1.20E-04
	900	1.46E-04	1.28E-04	2.25E-04	1.97E-04	1.46E-04	1.28E-04	6.21E-05	5.45E-05	2.15E-05	1.88E-05
Ground Application (high boom) Maximum Rate	0	1.02E+00	2.04E-01	**1.57E+00**	**3.14E-01**	**1.02E+00**	**2.04E-01**	**4.34E-01**	**8.68E-02**	**1.50E-01**	3.00E-02
	25	1.92E-02	5.45E-03	2.95E-02	8.38E-03	1.92E-02	5.45E-03	8.17E-03	2.32E-03	2.82E-03	8.01E-04
	100	5.41E-03	2.86E-03	8.32E-03	4.40E-03	5.41E-03	2.86E-03	2.30E-03	1.22E-03	7.96E-04	4.21E-04
	900	5.10E-04	4.49E-04	7.85E-04	6.91E-04	5.10E-04	4.49E-04	2.17E-04	1.91E-04	7.50E-05	6.60E-05
Aerial Application (non-forested) Typical Rate	0	2.92E-01	5.84E-02	**4.49E-01**	**8.98E-02**	**2.92E-01**	**5.84E-02**	**1.24E-01**	2.49E-02	4.29E-02	8.59E-03
	100	2.26E-02	3.15E-03	3.48E-02	4.85E-03	2.26E-02	3.15E-03	9.62E-03	1.34E-03	3.32E-03	4.63E-04
	300	8.29E-03	1.48E-03	1.28E-02	2.28E-03	8.29E-03	1.48E-03	3.53E-03	6.30E-04	1.22E-03	2.18E-04
	900	3.59E-03	6.83E-04	5.52E-03	1.05E-03	3.59E-03	6.83E-04	1.53E-03	2.91E-04	5.28E-04	1.00E-04
Aerial Application (non-forested) Maximum Rate	0	1.02E+00	2.04E-01	**1.57E+00**	**3.14E-01**	**1.02E+00**	**2.04E-01**	**4.34E-01**	**8.68E-02**	**1.50E-01**	3.00E-02
	100	7.90E-02	1.10E-02	**1.22E-01**	**1.69E-02**	**7.90E-02**	1.10E-02	3.36E-02	4.68E-03	1.16E-02	1.62E-03
	300	2.90E-02	5.16E-03	4.46E-02	7.94E-03	2.90E-02	5.16E-03	1.23E-02	2.20E-03	4.26E-03	7.59E-04
	900	1.25E-02	2.39E-03	1.92E-02	3.68E-03	1.25E-02	2.39E-03	5.32E-03	1.02E-03	1.84E-03	3.51E-04

[1] TES = Threatened, endangered, and sensitive species.
[2] Toxicity value = 0.65 mg/L (96-hour LC_{50} for rainbow trout).
[3] Toxicity value = 1 mg/L (96-hour LC_{50} for bluegill and fathead minnow).
[4] Toxicity value = 2.35 mg/L (48-hour LC_{50} for water flea).
[5] Toxicity value = 6.8 mg/L (96-hour LC_{50} for frogs [*Xenopus laevis*]).
[6] Values given in scientific notation. For example, 2.92E-01 equals 0.292; 5.84E-02 equals 0.0584, etc.
Shading and boldface indicates RQs greater than 0.05 (LOC for acute risk to endangered species – most conservative).
Impacted stream volume is 254,460 liters (2 meters wide, 0.2 meter deep, 636 meters long).
Impacted pond volume is 1,011,715 liters (1/4 acre pond, 1 meter deep).
Assumes typical and maximum application rates of 0.521 lbs/acre and 1.82 lbs/acre for POEA.

surfactants), doing so is impractical with currently available models (e.g., GLEAMS) and toxicity databases, which are designed to calculate deterministic risk calculations (i.e., exposure modeling, effects assessment, and risk calculations) for a single active ingredient.

To address this uncertainty, each ERA conducted by the BLM included a semi-quantitative assessment of the potential impacts of inert ingredients, adjuvants, and tank mixtures. This process included a review of Confidential Business Information (CBI) on inert compounds; a review of the adjuvants discussed on the herbicide label, with a modeling effort designed to assess the potential toxicity of adjuvants in surface runoff; and a quantitative assessment of selected tank mixes to evaluate the potential additive impacts of two herbicides applied together. Although it is also preferable to thoroughly evaluate the potential impacts of any chemicals produced over time during the degradation of the active ingredient, an assessment of the effects of these degradates has not been feasible.

In response to comments received on the Draft PEIS, an additional investigation was conducted to more thoroughly investigate the available information on degradates and to assess whether it is likely for degradates to be more toxic than the parent compounds (i.e., the active ingredients considered in the risk assessments), and whether it is feasible to evaluate the potential risk of degradates using the methods applied to the active ingredient. The following observations were made during this review:

- Degradates are often not identified or named in registration documents. The USEPA's Pesticide Fate Database (available online at http://www.epa.gov/oppefed1/general/databasedescription.htm) contains data from studies submitted by pesticide manufacturers in support of the registration or re-registration of their pesticide products. Of the 486 active ingredients listed in the database in August 2006, only 189 ingredients included fate studies.

- Degradates are often tentatively identified compounds. Even when the degradates are identified, the physical and chemical characteristics of the compounds are often poorly understood. For example, there is often little information available about toxicity or fate and transport of the degradate. Without this information, it is impossible to conduct a meaningful exposure assessment.

- Each active ingredient may break down into multiple degradates with varying toxicological and chemical properties. For the 19 active ingredients considered in this section, over 100 potential degradates were identified from the available registration materials. Investigating the characteristics of each of these degradates is an enormous task, and given the lack of available information, a comprehensive quantitative assessment is virtually impossible.

The specific suite of degradates produced varies with local environmental conditions, and the relative importance of degradates is often very small (i.e., only a few percent of the mass of the parent compound is represented in a single degradate). Together, these two factors make accounting for the impact of the degradates very difficult.

Table D-4 presents the names of the degradates identified during a review of registration documents, discussions with the USEPA, and communications with herbicide manufacturers. When available, additional information is also presented. In some cases, the materials reviewed provided toxicity information or information regarding the percentage of the parent compound that degraded into a given degradate and the length of time in which the degradate was produced. The percentage of the parent compound that degraded into the various degradates ranged widely, from 0.3 to 80.7%. There was also a wide range of production times for the degradates (12 hours to 365 days).

After the degradates were identified by name, an additional search was conducted for toxicity data. Searches focused on aquatic toxicity data for ecological receptors in the USEPA's ECOTOX database and reference doses for humans (searched in various databases, including USEPA's Integrated Risk Information System [IRIS], California EPA, and USEPA's National Center for Environmental Assessment). The results of these searches are discussed in the following subsections.

Aquatic Toxicity Review

In an effort to assess the potential toxicity of degradates to aquatic receptors, the USEPA's ECOTOX database (http://cfpub.epa.gov/ecotox/) was searched for the degradates listed in Table D-4. This database is a prime source of single chemical toxicity data for a variety of ecological receptors. The database is maintained by the USEPA Office of Research and Development (ORD), and the National Health and Environmental Effects Research Laboratory's (NHEERL's) Mid-Continent Ecology Division (MED). The focus of the toxicity data searches was on aquatic toxicity, in part because there is generally a wider body of toxicity testing conducted on aquatic species than on terrestrial species. In addition, due to similarities in testing methods and test organisms, it is easier to compare different sets of aquatic toxicity test results than to compare terrestrial tests conducted with widely different species. In order for the comparisons between toxicity data to be meaningful, it would be necessary to extrapolate the terrestrial toxicity test results to the body weight of the surrogate bird and mammal species selected for the development of toxicity reference values (TRVs) in each of the 19 risk assessments, which would add additional layers of uncertainty associated with interspecies variation.

Searches of the ECOTOX database identified relevant aquatic toxicity data for 10 degradates. Toxicity data were not considered relevant for comparison to the parent compound TRVs if the data were not presented on a water concentration basis (i.e., tissue data were not considered), if an effect concentration was not reported (NR), or if both the test duration and test endpoint were listed as NR in the database. The remaining aquatic toxicity data were compared against the aquatic TRVs selected for use in the BLM and Forest Service ERAs. These comparisons are presented in Figures D-1 through D-7. It should be noted that the values for the parent compounds presented in the figures represent the individual TRVs selected from a wide range of aquatic toxicity data reviewed during the ERA process. The full set of toxicity data considered in the derivation of the TRVs is presented in an appendix included with each ERA. In some cases, too many degradate toxicity values were found to include all data labels in the figures. In these cases, a set of representative labels are presented over the range of data points.

In most cases, the toxicity data for the degradates and the parent compound TRVs overlap and cover a similar range of concentrations. The lowest TRVs selected for diquat, diuron, imazapyr, and metsufuron methyl are below the lowest toxicity data point for the associated degradates. The parent compound TRVs are likely, therefore, to be sufficiently protective of potential aquatic impacts from degradates (see Figures D-2, D-3a, D-5, and D-6). These examples show that predicted risks for impacts due to degradates would likely be less than risks from the active ingredients evaluated in the ERAs.

The ECOTOX searches on degradates associated with 2,4-D, diuron, fluridone, and triclopyr identified individual toxicity data points below some of the TRVs for the active ingredients. In these cases, there may be selected aquatic species that are more sensitive to the degradate than to the active ingredient. However, this information should be considered in the context of the herbicide use practices, the concentration of the degradate relative to the parent compound, the process of degradate production, and the body of available toxicity data. For example, although the toxicity review identified aquatic toxicity data points for 3,4-dichlorobenzenamine (Figure D-3b; referred to as 3,4-dichloroaniline in Table D-4) below the TRVs for the parent compound (diuron), the registration materials indicate that only 0.5% of the parent compound degrades into 3,4-dichlorobenzenamine. Therefore, the increased toxicity of the degradate is offset by the fact that only a minute amount of the degradate is produced, which will likely disperse rapidly in an active aquatic system. A similar case exists for fluridone and the degradate benzoic acid (Figure D-4). There are also some uncertainties associated with the lowest water flea toxicity values identified for benzoic acid, since the toxicity endpoint is not defined. These toxicity values (1.95E-04 and 1.22E-03 mg/L) are also dramatically lower than other water flea toxicity values identified for benzoic acid (ranging from 146 mg/L to 1540 mg/L). Focusing on a single toxicity study may be overly conservative and may not be representative of risks found in the field or in other laboratory studies.

The ECOTOX search also indicated that aquatic risks to sensitive salmonids may be slightly higher for a triclopyr degradate (Figure D-7) than for the active ingredient itself. However, this dataset is limited to a series of studies presented in a single journal article in 1987. Aquatic risks associated with degradates of 2,4-D may also be higher than predicted risks for the parent compound under some conditions. Figure D-4 indicates that selected toxicity data points for 2,4-dichlorophenol and 4-chlorophenol are lower than the TRVs selected for 2,4-D. However, as with other degradates, the lowest toxicity data points may be overly conservative and may not represent the full range of toxicity data available. There are several fish, aquatic invertebrate, and aquatic macrophyte toxicity data points for 2,4-dichlorophenol and 4-chlorophenol, that are within the 0.3 mg/L to 100 mg/L range selected for the 2,4-D TRVs. However, the presence of lower toxicity data points for the degradates may indicate the need for additional caution when 2,4-D is applied in the vicinity of a water body. There remains a great deal of uncertainty, though, since the registration materials did not report information on the production time or proportion of parent degrading for 2,4-dichlorophenol and 4-chlorophenol.

Human Health Toxicity Review

A search for human health toxicity values was conducted for the degradates listed in Table D-4. USEPA's memorandum for the hierarchy of selection of toxicity data (USEPA 2003) was followed. Sources of toxicity data searched included:

1. Tier 1: The USEPA's Integrated Risk Information System (IRIS; USEPA 2006a). This online database (http://www.epa.gov/iris/) presents toxicity data that are peer reviewed and generally represent official USEPA position on the toxicity of the chemicals.

2. Tier 2: The USEPA's Provisional Peer Reviewed Toxicity Values (PPRTVs). PPRTVs are available from the National Center for Environmental Assessment with approval from a Superfund Remedial Project Manager, and can often be found in tables of compiled toxicity data, published by USEPA Region 3 (USEPA 2006b) or USEPA Region 9 (USEPA 2004a).

3. Tier 3: Other Sources, including the Agency for Toxic Substances (ATSDR) Minimal Risk Levels (ATSDR 2005), California Environmental Protection Agency values (CalEPA 2005a, 2005b) and the Health Effects Summary Tables (USEPA 1997).

The focus of the search was to determine whether the degradates have toxicity values (such as no observed adverse effect levels (NOAELs) or reference doses (RfDs)) that are derived by a regulatory agency. Identification of these toxicity values for the degradates would allow a comparison of toxicity with the parent compound. General toxicology information was not compiled for the degradates, as general information would not allow for a direct comparison of the toxicity of the degradate to the RfD used in the human health risk assessment for the parent chemical. The majority of the degradates do not have toxicity values derived by a regulatory agency. Only two of the listed degradates, benzoic acid and 4-chlorophenol, have relevant toxicity values, as discussed below.

Benzoic Acid

Benzoic acid is the only degradate of fluridone to have a published human health toxicity value. No cancer slope factor is available from the sources searched. Benzoic acid has an RfD of 4 mg/kg-day listed in IRIS (USEPA 2006a). This RfD is 50 times higher than the RfD listed for fluridone (0.08 mg/kilogram [kg]-day), which was also used as the Population Adjusted Dose (PAD) for evaluating dietary pathways in the EIS risk assessment. The higher RfD indicates that benzoic acid is less toxic than fluridone.

The BLM human health risk assessment (HHRA) for fluridone showed that fluridone risks could exceed the USEPA's level of concern for all occupational receptors under the accidental scenario, for an airplane mixer/loader under the routine use (maximum application rate) scenario for intermediate- and long-term exposures, and for a helicopter mixer/loader under the routine use (maximum application rate) scenario for long-term exposures. For public receptors, the HHRA showed that fluridone risks do not exceed the USEPA's level of concern under the routine-use typical application rate scenario, but could exceed the USEPA's level of concern for a nearby resident (adult and child) under the routine-use maximum application rate scenario, and for a nearby resident (adult and child), a berry picker (child) and a Native American (child) under the accidental scenarios.

Since benzoic acid is 50-fold less toxic than fluridone, it is likely that it would not show any risks above the USEPA's level of concern. The other herbicides evaluated in the PEIS risk assessment that have higher RfDs than fluridone did not show risks above the USEPA's level of concern.

4-Chlorophenol

4-chlorophenol is a degradate of 2,4-D. Although this chemical does not have a listed toxicity value from the sources searched, it is structurally similar to 2-chlorophenol. Therefore, the RfD available for 2-chlorophenol (0.005 mg/kg-day) from IRIS (USEPA 2006a) was used to evaluate 4-chlorophenol. The RfD for 2-chlorophenol is one-half that of the current RfD for 2,4-D (0.01 mg,/kg-day), indicating that 4-chlorophenol is twice as toxic as 2,4-D. No cancer slope factor is available from the sources searched.

Because 2,4-D was included in the 1991 BLM EIS, an updated risk assessment was not conducted for the current PEIS. However, the Forest Service conducted a risk assessment for 2,4-D that uses the current reference dose for 2,4-D (SERA 1998). Because 4-chlorophenol is twice as toxic as 2,4-D, it is expected that, at the same exposure concentration, the risks from 4-chlorophenol would be twice those predicted in the Forest Service risk assessment for 2,4-D. The Forest Service risk assessment for 2,4-D concluded that there could be some risks to workers at the highest estimate of exposure, but that these could be controlled by adequate protection. The risk assessment for 2,4-D concluded that that there should be no risks to the public except under accidental scenarios or after consumption of contaminated vegetables over several months, which the risk assessment stated is unlikely.

Degradation of 2,4-D yields only a fractional percentage of 4-chlorophenol on a molar basis, and 4-chlorophenol is degraded faster than 2,4-D. It is unlikely that concentrations of 4-chlorophenol in the environment produced from 2,4-D degradation would be on the same order of magnitude as the 2,4-D. Furthermore, according to the RED (USEPA 2005), the OPP Metabolism Assessment Review Committee (MARC) determined that all degradates of 2,4-D are not of risk concern due to low occurrence under environmental conditions, comparatively low toxicity, or both.

Conclusions

Although a fully quantitative evaluation of the potential risks associated with degradates using the methods followed for the active ingredient is not possible, a limited semi-quantitative comparison of the toxicity values was possible for both ecological and human health. The review of the relevant degradate toxicity information indicates that, in most cases where information was available, the TRVs used in the ERAs and the RfDs used in the human health risk assessment are protective of impacts (i.e., are low enough to predict potential impacts) due to the identified degradates. Most of the TRVs capture the full range of data identified during the aquatic toxicity review for the degradates, indicating that degradate toxicity is addressed by these TRVs.

The RfD identified for benzoic acid indicates that it is far less toxic than the parent compound (fluridone). There are a few exceptions where aquatic toxicity data for the degradates is lower than the TRVs used in the ERAs (2,4-D, diuron, fluridone, triclopyr) and one case (2,4-D) where the RfD for the degradate is lower than for the parent compound. There are some uncertainties associated with the degradate toxicity data in these examples (i.e., a surrogate RfD for 4-chlorophenol was used; some low aquatic toxicity data points appear to be outliers compared to the rest of the degradate data set). In these cases, the use of the herbicide may warrant additional precautions.

Potential Endocrine Disrupting Chemicals

According to the World Health Organization (2002), endocrine disrupters have been defined as exogenous substances that alter function(s) of the endocrine system and consequently cause adverse health effects in an intact organism or its progeny, or in (sub)populations. Endocrine disrupters interfere with the functioning of the endocrine system, in at least three possible ways:

- By mimicking the action of a naturally-produced hormone, such as estrogen or testosterone, and thereby setting off similar chemical reactions in the body;
- by blocking the receptors in cells receiving the hormones (hormone receptors), thereby preventing the action of normal hormones; or
- by affecting the synthesis, transport, metabolism and excretion of hormones, thus altering the concentrations of natural hormones.

During the toxicity review for the HHRAs and ERAs, no endocrine disrupting effects were noted. For the 10 BLM ERAs, the toxicity review consisted of a literature search and a review of USEPA registration data. In order to further evaluate whether any of the BLM herbicides have endocrine disruption effects, the BLM conducted a search of endocrine disrupter databases, including sources from the U.S., the European Union, and Japan. The databases included official government lists and lists published by concerned citizen groups, such as the Pesticide Action Network. The results of this search are presented in Table D-5. With the exception of 2,4-D and diuron, none of the BLM herbicides were included among those associated with endocrine disrupting effects. As shown in the table, diuron and 2,4-D are listed by the

European Commission Directorate-General for the Environment (2000) as Category 2 chemicals, meaning that there is evidence of the potential for the listed chemical to cause endocrine disruption. Diuron only appeared on a single list, so there is some uncertainty within the scientific community about this chemical's status as an endocrine disruptor.

Several other lists include 2,4-D as a potential or probably endocrine disrupting chemical. However, the Endocrine Disruptor Knowledge Base supported by the U.S. Food and Drug Administration's National Center for Toxicological Research indicates that there are no reports in the scientific peer-reviewed literature of 2,4-D acting as an estrogen receptor binder.

The USEPA Health Effects Division (HED) HHRA that was used in the RED, and a correction to the HED HHRA provided by the 2,4-D Industry Task Force, were reviewed. The HED HHRA and Task Force correction provided additional detail regarding the studies used to test for potential endocrine effects. In general, the studies cited as showing evidence of endocrine disruption effects were conducted using extremely high doses of 2,4-D, where often renal saturation or other systemic effects were noted. The findings of these studies, therefore, do not indicate that 2,4-D has selective toxicity to the endocrine system.

In the health risk assessment conducted to support the reregistration of 2,4-D (USEPA 2004c), the USEPA concluded that there is not sufficient evidence that 2,4-D is an endocrine disrupting chemical. The USEPA did not conduct the health risk assessment using endocrine disruption endpoints. Since the current studies that showed evidence of endocrine effects were tested using doses above renal saturation, the USEPA did recommended formal testing of 2,4-D for endocrine endpoints. However, there is no standard protocol for determination of endocrine effects of chemicals.

The lack of a standardized and broadly accepted set of protocols for identifying and quantifying potential endocrine effects has very important implications. The absence of such a test contributes to the development of several, potentially conflicting, summaries of potential endocrine disruptors. As importantly, in the absence of an agreed upon process to quantify dose-response relationships, quantitative risk assessments are difficult and highly uncertain.

TABLE D-4
Degradates Identified for Active Ingredients

Parent Compound	Degradate Name // [Synonym]	Mechanism of Production	Estimated Proportion of Parent	Production Time (Days)	Source
2,4-D	1,2,4-benzenetriol	Not reported	Not reported	Not reported	USEPA (2005)
2,4-D	2,4-dichlorophenol // [2,4-DCP]	Not reported	Not reported	Not reported	USEPA (2005)
2,4-D	2,4-dichloroanisole // [2,4-DCA]	Not reported	Not reported	Not reported	USEPA (2005)
2,4-D	4-chlorophenol	Not reported	Not reported	Not reported	USEPA (2005)
2,4-D	Chlorohydroquinone // [CHQ]	Not reported	Not reported	Not reported	USEPA (2005)
Bromacil	3-sec-butyl-6-methyluracil // [Metabolite F]	Aerobic soil metabolism	0.70%	304	USEPA (1996)
Bromacil	3-sec-butyl-6-methyluracil // [Metabolite F]	Anaerobic aquatic metabolism	80.7%	304	USEPA (1996)
Bromacil	5-bromo-3-(2-hydroxy-1-methylpropyl)-6-methyluracil // [Metabolite D]	Aerobic soil metabolism	0.80%	304	USEPA (1996)
Bromacil	5-bromo-3-(alpha-hydroxymethylpropyl)-6-methyluracil // [Metabolite C]	Aerobic soil metabolism	1.5%	154	USEPA (1996)
Bromacil	5-bromo-3-(alpha-hydroxymethylpropyl)-6-methyluracil // [Metabolite C]	Aerobic soil metabolism	1.5%	184	USEPA (1996)
Bromacil	5-bromo-3-sec-butyl-6-hyroxymethyluracil // [Metabolite A]	Aerobic soil metabolism	0.60%	184	USEPA (1996)
Bromacil	5-bromo-6-methyluracil // [Metabolite G]	Aerobic soil metabolism	3.4%	304	USEPA (1996)
Bromacil	8 unidentified degradates	Photodegradation in water	<8.1% Each	102	USEPA (1996)
Bromacil	Peak II	Hydrolysis	3.90%	30	USEPA (1996)
Bromacil	Unknown I	Photodegradation on soil	<2.5%	30	USEPA (1996)
Bromacil	Unknown I	Soil in dark	<2.0%	30	USEPA (1996)
Bromacil	Unknown II	Photodegradation on soil	<2.5%	30	USEPA (1996)
Bromacil	Unknown II	Soil in dark	<2.0%	30	USEPA (1996)

TABLE D-4 (Cont.)
Degradates Identified for Active Ingredients

Parent Compound	Degradate Name // [Synonym]	Mechanism of Production	Estimated Proportion of Parent	Production Time (Days)	Source
Chlorsulfuron	2-amino-4-methoxy-6-methyl-1,3,5-triazine	Aerobic soil metabolism	15%	50	USEPA (2004a)
Chlorsulfuron	2-chlorobenzenesulfonamide	Aerobic soil metabolism	30-35%	50	USEPA (2004b)
Chlorsulfuron	2-chloro-N-[[(4-hydroxy-6-methyl-1,3,5-triazin-2-yl)-amino]carbonyl]benzenesulfonamide	Aerobic soil metabolism	15%	50	USEPA (2004b)
Chlorsulfuron	Chlorosulfonamide	Hydrolysis	33%	31	USEPA (2004b)
Chlorsulfuron	Dihydroxy triazine	Hydrolysis	<10%	31	USEPA (2004b)
Chlorsulfuron	Dihydroxy triazine	Soil photodegradation	<10%	65	USEPA (2004b)
Chlorsulfuron	N-(2-chlorobenzenesulfonyl)carbamic acid	Degradation on soil	Not reported		Marucchini et al. (1991)
Chlorsulfuron	O-desmethylchlosulfuron	Hydrolysis	10%	31	USEPA (2004b)
Chlorsulfuron	O-desmethylchlosulfuron	Soil photodegradation	<10%	65	USEPA (2004b)
Chlorsulfuron	Ring-opened chlorosulfuron	Hydrolysis	16%	31	USEPA (2004b)
Chlorsulfuron	Triazine	Hydrolysis	<10%	31	USEPA (2004b)
Chlorsulfuron	Triazine amine	Soil photodegradation	<10%	65	USEPA (2004b)
Chlorsulfuron	Triazine urea	Soil photodegradation	<10%	65	USEPA (2004b)
Clopyralid [1]					
Dicamba [2]	3,6-dichlorosalicylic acid // [3,6-DCSA]	Aerobic soil metabolism	≤14.5%	365	Wendt et al. (1994)
Diflufenzopyr [2]	1-(3,5-difluorophenyl)urea // [M4]	Aerobic soil metabolism of phenyl labeled diflufenzopyr	5.82%	312	Singh et al. (2001)
Diflufenzopyr [2]	2-acetylnicotinic acid // [M6]	Aqueous photolysis of pyridine labeled Diflufenzopyr	>6.4%	20	Mills et al. (2001)
Diflufenzopyr [2]	2-acetylnicotinic acid // [M6]	Dark control for aqueous photolysis experiments	Not reported	20	Mills et al. (2001)

TABLE D-4 (Cont.)
Degradates Identified for Active Ingredients

Parent Compound	Degradate Name // [Synonym]	Mechanism of Production	Estimated Proportion of Parent	Production Time (Days)	Source
Diflufenzopyr [2]	2-acetylnicotinic acid // [M6]	Aerobic soil metabolism of pyridine labeled diflufenzopyr	4.25%	312	Singh et al. (2001)
Diflufenzopyr [2]	3,5-difluoroaniline // [M2]	Aqueous photolysis of phenyl labeled diflufenzopyr	>6%	20	Mills et al. (2001)
Diflufenzopyr [2]	3,5-difluoroaniline // [M2]	Dark control for aqueous photolysis experiments	Not reported	20	Mills et al. (2001)
Diflufenzopyr [2]	3,5-difluoroaniline // [M2]	Aerobic soil metabolism of phenyl labeled diflufenzopyr	<2%	312	Singh et al. (2001)
Diflufenzopyr [2]	7-methylfuro[3,4-b]pyridin-5(7h)-one // [M24]	Aqueous photolysis of pyridine labeled diflufenzopyr	>6.4%	20	Mills et al. (2001)
Diflufenzopyr [2]	8-methylpyrido[2,3-d]pyridazin-5(6h)-one // [M1]	Aqueous photolysis of pyridine labeled diflufenzopyr	>6.4%	20	Mills et al. (2001)
Diflufenzopyr [2]	8-methylpyrido[2,3-d]pyridazin-5(6h)-one // [M1]	Dark control for aqueous photolysis experiments	Not reported	20	Mills et al. (2001)
Diflufenzopyr [2]	8-methylpyrido[2,3-d]pyridazin-5(6h)-one // [M1]	Aerobic soil metabolism of pyridine labeled diflufenzopyr	1.9 - 13.15%	312	Singh et al. (2001)
Diflufenzopyr [2]	8-methylpyrido[2,3-d]pyridazine-2,5(1h,6h)-dione // [M9]	Aerobic soil metabolism of pyridine labeled diflufenzopyr	26%	312	Singh et al. (2001)
Diflufenzopyr [2]	N-(3,5-difluorophenyl)-7-methyl-5-oxo-5,7-dihydrofuro[3,4-b]pyridine-7-carboxamide // [M23]	Aqueous photolysis of pyridine labeled diflufenzopyr	>6.4%	20	Mills et al. (2001)
Diflufenzopyr [2]	N-(3,5-difluorophenyl)-7-methyl-5-oxo-5,7-dihydrofuro[3,4-b]pyridine-7-carboxamide // [M23]	Aqueous photolysis of phenyl labeled diflufenzopyr	>6%	20	Mills et al. (2001)
Diflufenzopyr [2]	N-(3,5-difluorophenyl)-7-methyl-5-oxo-5,7-dihydrofuro[3,4-b]pyridine-7-carboxamide // [M23]	Aerobic soil metabolism of phenyl labeled diflufenzopyr	<2%	312	Singh et al. (2001)
Diflufenzopyr [2]	N-(3,5-difluorophenyl)-8-methyl-5-oxopyrido[2,3-d]pyridazine-6(5H)-carboxamide // [M5]	Aerobic soil metabolism of phenyl labeled diflufenzopyr	3.89%	312	Singh et al. (2001)
Diflufenzopyr [2]	N-(3,5-difluorophenyl)-8-methyl-5-oxopyrido[2,3-d]pyridazine-6(5H)-carboxamide // [M5]	Aerobic soil metabolism of pyridine labeled diflufenzopyr	3.22%	312	Singh et al. (2001)
Diflufenzopyr [2]	N-(3,5-difluorophenyl)hydrazinecarboxamide // [M7]	Aqueous photolysis of phenyl labeled diflufenzopyr	>6%	20	Mills et al. (2001)

TABLE D-4 (Cont.)
Degradates Identified for Active Ingredients

Parent Compound	Degradate Name // [Synonym]	Mechanism of Production	Estimated Proportion of Parent	Production Time (Days)	Source
Diflufenzopyr [2]	P1	Aqueous photolysis of phenyl labeled diflufenzopyr	>6%	20	Mills et al. (2001)
Diflufenzopyr [2]	P11	Aqueous photolysis of phenyl labeled diflufenzopyr	>6%	20	Mills et al. (2001)
Diflufenzopyr [2]	P2	Aqueous photolysis of phenyl labeled diflufenzopyr	>6.4%	20	Mills et al. (2001)
Diflufenzopyr [2]	P5	Aqueous photolysis of phenyl labeled diflufenzopyr	>6.4%	20	Mills et al. (2001)
Diflufenzopyr [2]	P9	Aqueous photolysis of phenyl labeled diflufenzopyr	>6%	20	Mills et al. (2001)
Diflufenzopyr [2]	P9	Dark control for aqueous photolysis experiments	Not reported	20	Mills et al. (2001)
Diflufenzopyr [2]	PH1	Aerobic soil metabolism of phenyl labeled diflufenzopyr	<2%	312	Singh et al. (2001)
Diflufenzopyr [2]	PH2	Aerobic soil metabolism of phenyl labeled diflufenzopyr	4.02%	312	Singh et al. (2001)
Diflufenzopyr [2]	PH3	Aerobic soil metabolism of phenyl labeled diflufenzopyr	<2%	312	Singh et al. (2001)
Diflufenzopyr [2]	PH4	Aerobic soil metabolism of phenyl labeled diflufenzopyr	<2%	312	Singh et al. (2001)
Diflufenzopyr [2]	PH5	Aerobic soil metabolism of phenyl labeled diflufenzopyr	<2%	312	Singh et al. (2001)
Diflufenzopyr [2]	PY1	Aerobic soil metabolism of pyridine labeled diflufenzopyr	<2%	312	Singh et al. (2001)
Diflufenzopyr [2]	PY2	Aerobic soil metabolism of pyridine labeled diflufenzopyr	<2%	312	Singh et al. (2001)
Diflufenzopyr [2]	PY3	Aerobic soil metabolism of pyridine labeled diflufenzopyr	<2%	312	Singh et al. (2001)
Diflufenzopyr [2]	PY4	Aerobic soil metabolism of pyridine labeled diflufenzopyr	<2%	312	Singh et al. (2001)
Diflufenzopyr [2]	PY5	Aerobic soil metabolism of pyridine labeled diflufenzopyr	<2%	312	Singh et al. (2001)
Diquat	1,2,3,4-tetrahydro-1-oxopyrido (1,2-a)pyrazin-5-ium	Photodegradation in water	12%	74	USEPA (1995a)

TABLE D-4 (Cont.)
Degradates Identified for Active Ingredients

Parent Compound	Degradate Name // [Synonym]	Mechanism of Production	Estimated Proportion of Parent	Production Time (Days)	Source
Diquat	1,2,3,4-tetrahydro-1-oxopyrido [1,2-a] -5-pyrazinium	Photodegradation	70% degradation of parent, major degradate along with picolinic acid	21	Smith and Grove (1969)
Diquat	Picolinic acid	Photodegradation	70% degradation of parent, major degradate along with 1,2,3,4-tetrahydro-1-oxopyrido [1,2-a] -5-pyrazinium	21	Smith and Grove (1969)
Diquat	Unknown compound	Anaerobic aquatic metabolism	5%	270	USEPA (1995a)
Diuron	3,3',4,4'-tetrachloroazobenzene // [TCAB]	Photodegradation in soil	Not reported	173	USEPA (2001)
Diuron	3,4-dichloroaniline // [3,4-DCA]	Hydrolysis	0.50%	30	USEPA (2001)
Diuron	CO2 and 13 minor polar products	Photodegradation in water	Each <9%	15	USEPA (2001)
Diuron	Dichloroaniline // [DCA]	Photodegradation in soil	Not reported	173	USEPA (2001)
Diuron	N'-(3,4-dichlorophenyl)-N-methylurea // [DCPMU]	Photodegradation in soil	Not reported	173	USEPA (2001)
Fluridone	1-methyl-3-(4-hydroxyphenyl)-5-[3-(trifluoromethyl)phenyl]-4-(1h)-pyridinone	Fish tissue residue (bioconcentration factor: edible 0.23; Inedible 4.16; whole body 3.07)	Not reported		West et al. (1983)
Fluridone	3-(trifluoromethyl)benzoic acid	Aqueous photolysis distilled water	24%	27	Saunders and Mosier. 1983.
Fluridone	3-(trifluoromethyl)benzoic acid	Aqueous photolysis lake water	33%	21	Saunders and Mosier (1983)
Fluridone	Benzoic acid	Aqueous photolysis distilled water	11%	7	Saunders and Mosier (1983)
Fluridone	Benzoic acid	Aqueous photolysis distilled water	0.30%	27	Saunders and Mosier (1983)
Fluridone	Benzoic acid	Aqueous photolysis lake water	40%	21	Saunders and Mosier (1983)

TABLE D-4 (Cont.)
Degradates Identified for Active Ingredients

Parent Compound	Degradate Name // [Synonym]	Mechanism of Production	Estimated Proportion of Parent	Production Time (Days)	Source
Fluridone	N-methylformamide	Aqueous photolysis distilled water	36%	27	Saunders and Mosier (1983)
Fluridone	N-methylformamide	Aqueous photolysis lake water	74%	27	Saunders and Mosier (1983)
Fluridone	No degradates detected at DL of 1 ppb	Field application	Not reported	Not reported	Smith et al. (1991)
Fluridone	No degradates detected at DL of 2 ppb	Field application	Not reported	Not reported	Osborne et al. (1989)
Fluridone	No degradates detected at DL of 5 ppb	Field application	Not reported	Not reported	West et al. (1990)
Fluridone	No specific degradate information found	Not reported	Not reported	Not reported	
Fluridone	Review article, no additional information.	Not reported	Not reported	Not reported	McLaren/Hart (1995)
Glyphosate	Alpha-**a**mino-3-hydroxy-5-**m**ethyl-4-isoxazole**p**ropionic **a**cid	Aerobic soil metabolism	Major	Not reported	USEPA (1993)
Glyphosate	Alpha-**a**mino-3-hydroxy-5-**m**ethyl-4-isoxazole**p**ropionic **a**cid	Anaerobic aquatic metabolism	Major	Not reported	USEPA (1993)
Glyphosate	Alpha-**a**mino-3-hydroxy-5-**m**ethyl-4-isoxazole**p**ropionic **a**cid	Aerobic aquatic metabolism	Major	Not reported	USEPA (1993)
Hexazinone	3-(2-hydroxycyclohexyl)-6-(dimethyl-amino-1-methyl-1,3,5-triazine-2,4(1H,3H)-dione	Aerobic aquatic metabolism	<7%	Not reported	USEPA (1994a)
Hexazinone	3-(4-ketycyclohexyl)-6-(dimethylamino)-1-methyl-1,3,5-triazine-2,4(1H,3H)-dione	Aerobic aquatic metabolism	<7%	Not reported	USEPA (1994a)
Hexazinone	3-(cyclohexyl-6-(methylamino)-1-methyl-1,3,5-triazine-2,4(1H,3H)-dione	Aerobic aquatic metabolism	<7%	Not reported	USEPA (1994a)
Hexazinone	3-(ketocyclohexyl)-6-(dimethylamino)-1-methyl-1,3,5-triazine-2,4(1H,3H)-dione	Aerobic soil metabolism	10.9%	Not reported	USEPA (1994a)
Hexazinone	3-(ketocyclohexyl)-6-(dimethylamino)-1-methyl-1,3,5-triazine-2,4(1H,3H)-dione	Anaerobic aquatic metabolism	25%	Not reported	USEPA (1994a)
Hexazinone	3-cyclohexyl-1-methyl-1,3,5-triazine-2,4,6-(1H,3H,5H)-trione	Anaerobic aquatic metabolism	24%	Not reported	USEPA (1994a)
Hexazinone	3-hydroxy-cyclohexyl-6-(dimethylamino)-1-methyl-1,3,5-triazine-2,4(1H-3H)-dione	Aerobic soil metabolism	18.7%	Not Reported	USEPA (1994a)

TABLE D-4 (Cont.)
Degradates Identified for Active Ingredients

Parent Compound	Degradate Name // [Synonym]	Mechanism of Production	Estimated Proportion of Parent	Production Time (Days)	Source
Hexazinone	3-hydroxy-cyclohexyl-6-(dimethylamino)-1-methyl-1,3,5-triazine-2,4(1H-3H)-dione	Anaerobic aquatic metabolism	5.5%	Not reported	USEPA (1994a)
Hexazinone	Metabolite B	Aerobic soil metabolism	2.3%	Not reported	USEPA (1994a)
Hexazinone	Metabolite D	Aerobic soil metabolism	4.8%	Not reported	USEPA (1994a)
Imazapic	2-[(1-carbamoyl-1,2-dimethylpropyl) carbamoyl]-5-methyl-nicotinic acid	Aqueous photolysis	41.3%	<0.5	New York State Department of Environmental Conservation (NYSDEC; 2004)
Imazapic	2-carbamoyl-5-methyl-3-nicotinic acid	Aqueous photolysis	44.3%	<0.5	NYSDEC (2004)
Imazapic	2-carbamoyl-5-methyl-nicotinic acid	Aqueous photolysis	12.9%	<0.5	NYSDEC (2004)
Imazapic [4]	3,5-pyridinedicarboxylic acid, 2-4(4-isopropyl-4-methyl-5-oxo-2-imidazolin-2-yl)- // [CL 312622]	Aerobic soil metabolism	<10%	Not reported	BASF (Undated)
Imazapic	5-methyl-2,3-pyridine dicarboxylic acid	Aqueous photolysis	13%	<0.5	NYSDEC (2004)
Imazapic	5-methyl-3-pyridine carboxylic acid	Aqueous photolysis	29.9%	<0.5	NYSDEC (2004)
Imazapic [4]	Nicotinic acid, 5-hydroxy-6-(4-isopropyl-4-methyl-5-oxo-2-imidazolin-2-yl)- // [CL354825]	Aerobic soil metabolism	<10%	Not reported	BASF (Undated)
Imazapyr	Nicotinic acid	Aqueous photolysis	Not reported	3 - 5	USEPA (2006c)
Imazapyr	Pyridine dicarboxylic acid	Aqueous photolysis	Not reported	3 - 5	USEPA (2006c)
Imazapyr	Pyridine hydroxy-dicarboxylic acid	Aqueous photolysis	Not reported	3 - 5	USEPA (2006c)
Metsulfuron methyl [5]	(4-Methoxy-6-methyl-1,3,5-triazin-2-yl]urea	Only seen in one field study where material balance was highly variable	Not reported		E.I. DuPont (2006a)

TABLE D-4 (Cont.)
Degradates Identified for Active Ingredients

Parent Compound	Degradate Name // [Synonym]	Mechanism of Production	Estimated Proportion of Parent	Production Time (Days)	Source
Metsulfuron methyl [5]	1,2-benzisothiazol-3(2h)-one, 1,1-dioxide	Not reported	Not reported	3 - 198	E.I. DuPont (2006b, c, d, e)
Metsulfuron methyl [6]	2-(aminosulfonyl)benzoic acid	Not reported	Not reported	22	E.I. DuPont (2006f)
Metsulfuron methyl [6]	2-[[(aminocarbonyl)amino]sulfonyl] benzoic acid, methyl ester	Not reported	Not reported	9 - 57	E.I. DuPont (2006g)
Metsulfuron methyl [7]	2-[[[[(4-methoxy-6-methyl-1,3,5-triazin-2-yl)amino]carbonyl]amino]sulfonyl]benzoic acid	Only seen above 10% in one field study where material balance was highly variable	Not reported		E.I. DuPont (2006a)
Metsulfuron methyl [6]	4-methoxy-6-methyl-1,3,5-triazin-2-amine	Not reported	Not reported	22 - 39	E.I. DuPont (2006h)
Metsulfuron methyl [6]	Methyl 2-(aminosulfonyl)benzoate	Not reported	Not reported	2 - 29	E.I. DuPont (2006b, d, g)
Metsulfuron methyl [8]	Methyl 2-[[[[(4-methoxy-6-methyl-1,3,5-triazin-2-yl) amino]carbonyl]amino]sulfonyl]benzoate	Not reported	Not reported	11 - 38	E.I. DuPont (2006b, f, g, i)
Metsulfuron methyl [9]	Methyl 2-[[[[(4-methoxy-6-methyl-1,3,5-triazin-2-yl) amino]carbonyl]amino]sulfonyl]benzoate	Not reported	Not reported	28 - 30	E.I. DuPont (2006j)
Metsulfuron methyl [10]	Methyl 2-[[[[[[(acetylamino)carbonyl]amino]carbonyl] amino]carbonyl]amino]sulfonyl]benzoate	Only seen in one field study where material balance was highly variable	Not reported	Not reported	E.I. DuPont (2006a)
Metsulfuron methyl [5]	Methyl 2-[[[[amino(aminocarbonyl)amino]methyl]amino]carbonyl]amino]sulfonyl]benzoate	Not reported	Not reported	16 - 53	E.I. DuPont (2006k)
Picloram	4-amino-2,3,5-trichloro pyridine	Aerobic soil metabolism	Minor	Not reported	USEPA (1995b)
Picloram	4-amino-3,5--dichloro-2-pyridinol	Aerobic soil metabolism	Minor	Not reported	USEPA (1995b)
Sulfometuron methyl [5]	1,2-benzisothiazol-3(2h)-one, 1,1-dioxide	Not reported	Not reported	3 - 198	E.I. DuPont (2006l)

TABLE D-4 (Cont.)
Degradates Identified for Active Ingredients

Parent Compound	Degradate Name // [Synonym]	Mechanism of Production	Estimated Proportion of Parent	Production Time (Days)	Source
Sulfometuron methyl	2-(aminosulfonyl)benzoic acid	Not reported	Not reported	Not reported	Information Ventures, Inc. (1995)
Sulfometuron methyl [6]	2-(aminosulfonyl)benzoic acid	Not reported	Not reported	22	E.I. DuPont (2006l)
Sulfometuron methyl [6]	2-[[(aminocarbonyl)amino]sulfonyl] benzoic acid, methyl ester	Not reported	Not reported	9 - 57	E.I. DuPont (2006l, m)
Sulfometuron methyl [6]	4,6-dimethyl-2-pyrimidinamine	Not reported	Not reported	48	E.I. DuPont (2006m)
Sulfometuron methyl [5]	4,6-dimethyl-2-pyrimidinol	Not reported	Not reported	312	E.I. DuPont (2006m)
Sulfometuron methyl [6]	Methyl 2-(aminosulfonyl)benzoate	Not reported	Not reported	2 - 29	E.I. DuPont (2006m)
Sulfometuron methyl [8]	Methyl 2-[[[[(4,6-dimethyl-2-pyrimidinyl)amino]carbonyl]amino]=sulfonyl]benzoate	Not reported	Not reported	20 - 26	E.I. DuPont (2006l, m)
Sulfometuron methyl	Methyl-2-(amino-sulfonyl)benzoate	Not reported	Not reported	Not reported	Information Ventures, Inc. (1995)
Sulfometuron methyl	Methyl-2-[[(aminocarbonyl)amino]sulfonyl] benzoate	Not reported	Not reported	Not reported	Information Ventures, Inc. (1995)
Sulfometuron methyl	Saccharin	Not reported	Not reported	Not reported	Information Ventures, Inc. (1995)
Tebuthiuron	5-(1,1-dimethylethyl)-2 amino-1,3,4-thiadiazol // [Compound 108]	Aerobic soil metabolism	Not reported	Not reported	USEPA (1994b)
Tebuthiuron	5-(1,1-dimethylethyl)-2 amino-1,3,4-thiadiazol // [Compound 108]	Aerobic aquatic metabolism	Sum of 5 products = 4.8%	28	USEPA (1994b)
Tebuthiuron	5-(1,1-dimethylethyl)-2 methylamino-1,3,4-thiadiazol // [Compound 107]	Aerobic soil metabolism	Not reported	Not reported	USEPA (1994b)
Tebuthiuron	5-(1,1-dimethylethyl)-2 methylamino-1,3,4-thiadiazol // [Compound 107]	Aerobic aquatic metabolism	Sum of 5 products = 4.8%	28	USEPA (1994b)

TABLE D-4 (Cont.)
Degradates Identified for Active Ingredients

Parent Compound	Degradate Name // [Synonym]	Mechanism of Production	Estimated Proportion of Parent	Production Time (Days)	Source
Tebuthiuron	N-[5-(1,1-dimethylethyl)-1,3,4-thiadiazol-2-y1]-N-methyl-N'-hydroxymethyl-urea // [Compound 109]	Anaerobic soil metabolism	Sum of 3 products = 4.7%	60	USEPA (1994b)
Tebuthiuron	N-[5-(1,1-dimethylethyl)-1,3,4-thiadiazol-2-y1]-N-methyl-N'-hydroxymethyl-urea // [Compound 109]	Aerobic aquatic metabolism	Sum of 5 products = 4.8%	28	USEPA (1994b)
Tebuthiuron	N-[5-1(1,1-dimethylethyl)-1,3,4-thiadiazol-2-y1]-N'-methylurea // [Compound 105]	Aerobic soil metabolism	Not reported	Not reported	USEPA (1994b)
Tebuthiuron	N-[5-1(1,1-dimethylethyl)-1,3,4-thiadiazol-2-y1]-N'-methylurea // [Compound 105]	Anaerobic soil metabolism	Sum of 3 products = 4.7%	60	USEPA (1994b)
Tebuthiuron	N-[5-1(1,1-dimethylethyl)-1,3,4-thiadiazol-2-y1]-N'-methylurea // [Compound 105]	Aerobic aquatic metabolism	Sum of 5 products = 4.8%	28	USEPA (1994b)
Tebuthiuron	N-[5-1(1,1-dimethylethyl)-1,3,4-thiadiazol-2-y1]-N-methylurea // [Compound 104]	Aerobic soil metabolism	6.9	270	USEPA (1994b)
Tebuthiuron	N-[5-1(1,1-dimethylethyl)-1,3,4-thiadiazol-2-y1]-N-methylurea // [Compound 104]	Anaerobic soil metabolism	Sum of 3 products = 4.7%	60	USEPA (1994b)
Tebuthiuron	N-[5-1(1,1-dimethylethyl)-1,3,4-thiadiazol-2-y1]-N-methylurea // [Compound 104]	Aerobic aquatic metabolism	Sum of 5 products = 4.8%	28	USEPA (1994b)
Triclopyr	Oxamic acid	Photodegradation in water	16%	0.7 - 1.7	USEPA (1998)
Triclopyr [3]	(5/6)-chloro-3-hydroxy-s-pyridinone	Photodegradation in water	17%	30	USEPA (1998)
Triclopyr [3]	3,5,6-trichloro-2-methoxypyridine // [TMP]	Aerobic soil metabolism	8%	<30	USEPA (1998)
Triclopyr [3]	3,5,6-trichloro-2-pyridinol // [TCP]	Aerobic soil metabolism	26%	<30	USEPA (1998)
Triclopyr [3]	3,5,6-trichloro-2-pyridinol // [TCP]	Aerobic aquatic metabolism	<5%	30	USEPA (1998)
Triclopyr [3]	5-chloro-3,6-dihydroxy-2-pyridinyloxyacetic acid	Photodegradation in water	48%	0.7 - 1.7	USEPA (1998)
Triclopyr [3]	At least 15 non-volatile compounds (not identified)	Photodegradation in water	10% total	30	USEPA (1998)
Triclopyr [3]	Dichloropyridinyloxyacetic acid, 2hydroxy ethyl ester	Photodegradation in water	6%	30	USEPA (1998)
Triclopyr [3]	Organic volatiles	Photodegradation in water	1.6% total	30	USEPA (1998)

TABLE D-4 (Cont.)
Degradates Identified for Active Ingredients

[1] The BLM has discussed the formation and identification of clopyralid degradates with the herbicide's manufacturer, Dow AgroSciences. Dow AgroSciences has performed relevant tests of environmental degradation in aerobic soils using radio-labeled clopyralid. The major finding of these studies was that clopyralid in aerobic soils had a short half life (i.e., 8 days) and that mineralization to carbon dioxide was very efficient. Consistent with this finding, 74% of the applied radio label was found as carbon dioxide. Less than 10% of the applied parent was found as a group of transient polar daughter compounds. No degradate was present at more than 8% of the parent compound's mass. Nonextractable, bound residues associated with humic and fulvic acid fractions represented as much as 8% of applied radio-labeled material. Given the low levels of degradates, characterization was not attempted, consistent with USEPA guidelines.

[2] Diflufenzopyr and dicamba are the active ingredients in the herbicide Overdrive®, which was evaluated by the BLM.

[3] Also includes triclopyr acid.

[4] Not toxic, rat LD_{50} oral >2,000 mg/kg.

[5] Not tested. Not considered herbicidal.

[6] No plant toxicity observed at highest concentration tested (2.0 kg/hectare [ha]).

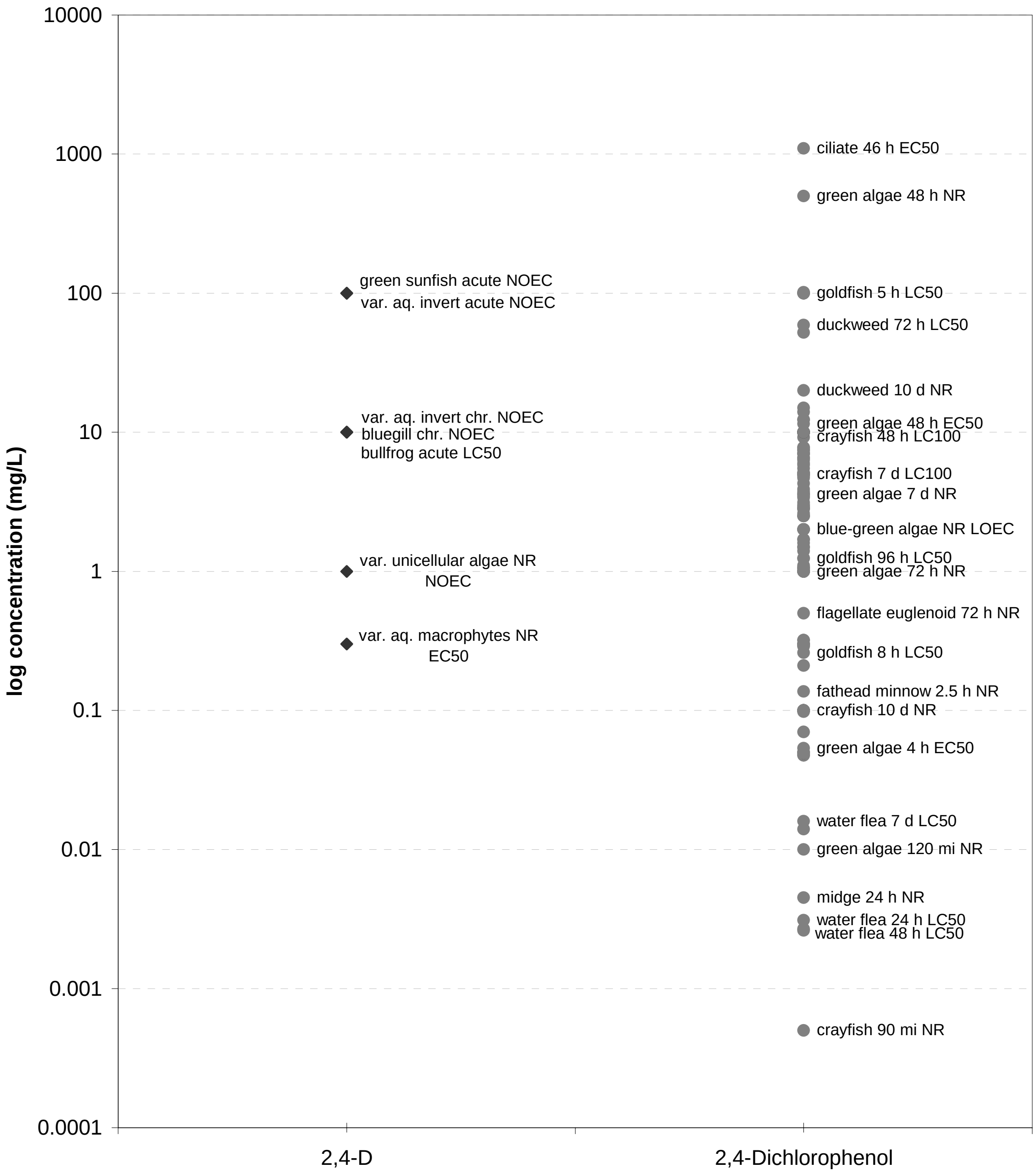
[7] Effects on morning glory observed at highest tested concentration (0.05 kg/ha). No effects observed on other plants.

[8] Herbicidal.

[9] Some effects observed on plants at highest concentration tested (0.05 kg/ha).

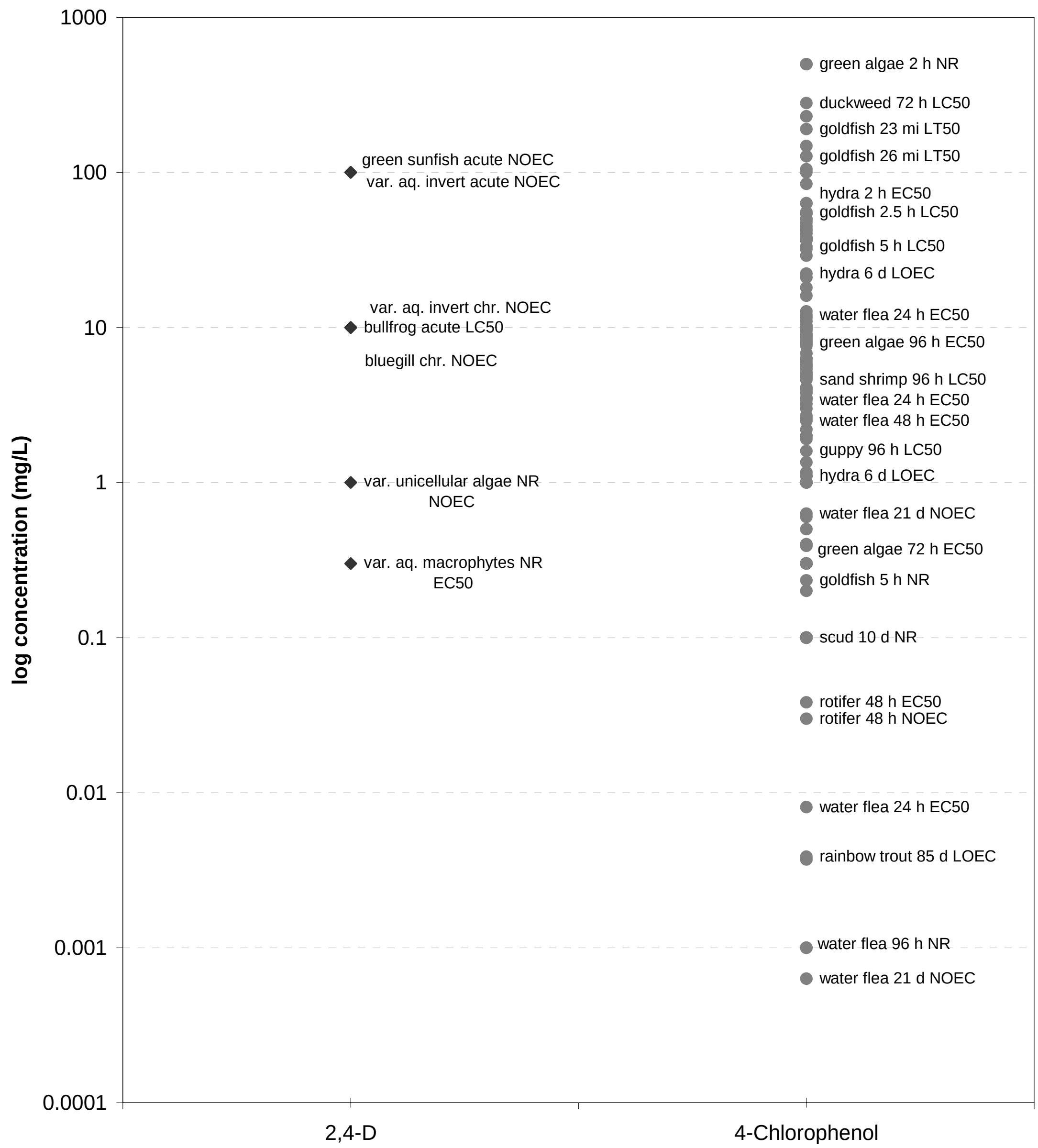
[10] No plant toxicity observed at highest concentration tested (0.1 kg/ha).

FIGURE D-1a
Aquatic Toxicity – 2,4-D Toxicity Reference Values and Degradate Toxicity Data



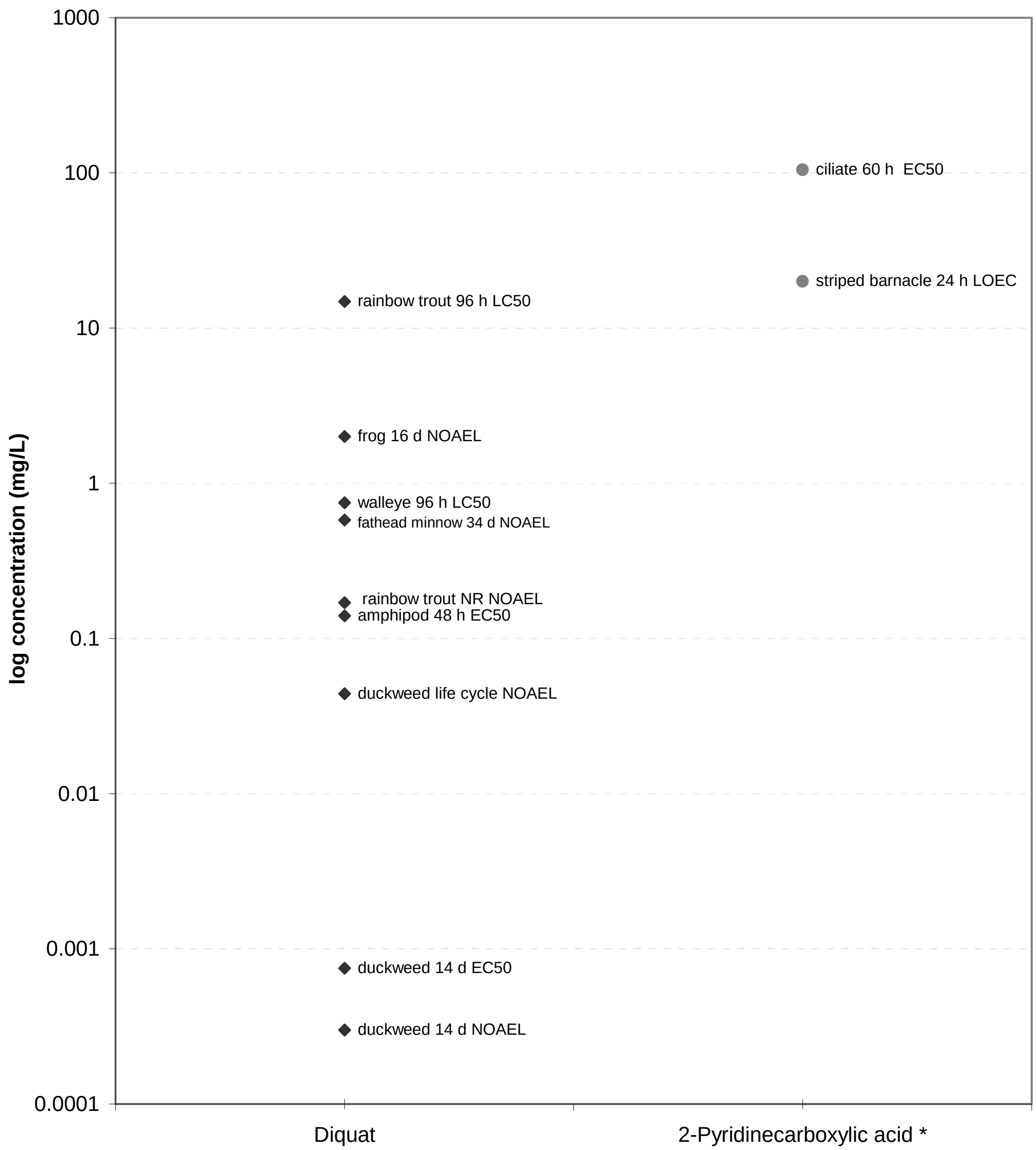
Label represents test organism, test duration, and endpoint.
Not all test organism names listed due to lack of space.
NR indicates duration or endpoint not reported.

FIGURE D-1b
Aquatic Toxicity – 2,4-D Toxicity Reference Values and Degradate Toxicity Data



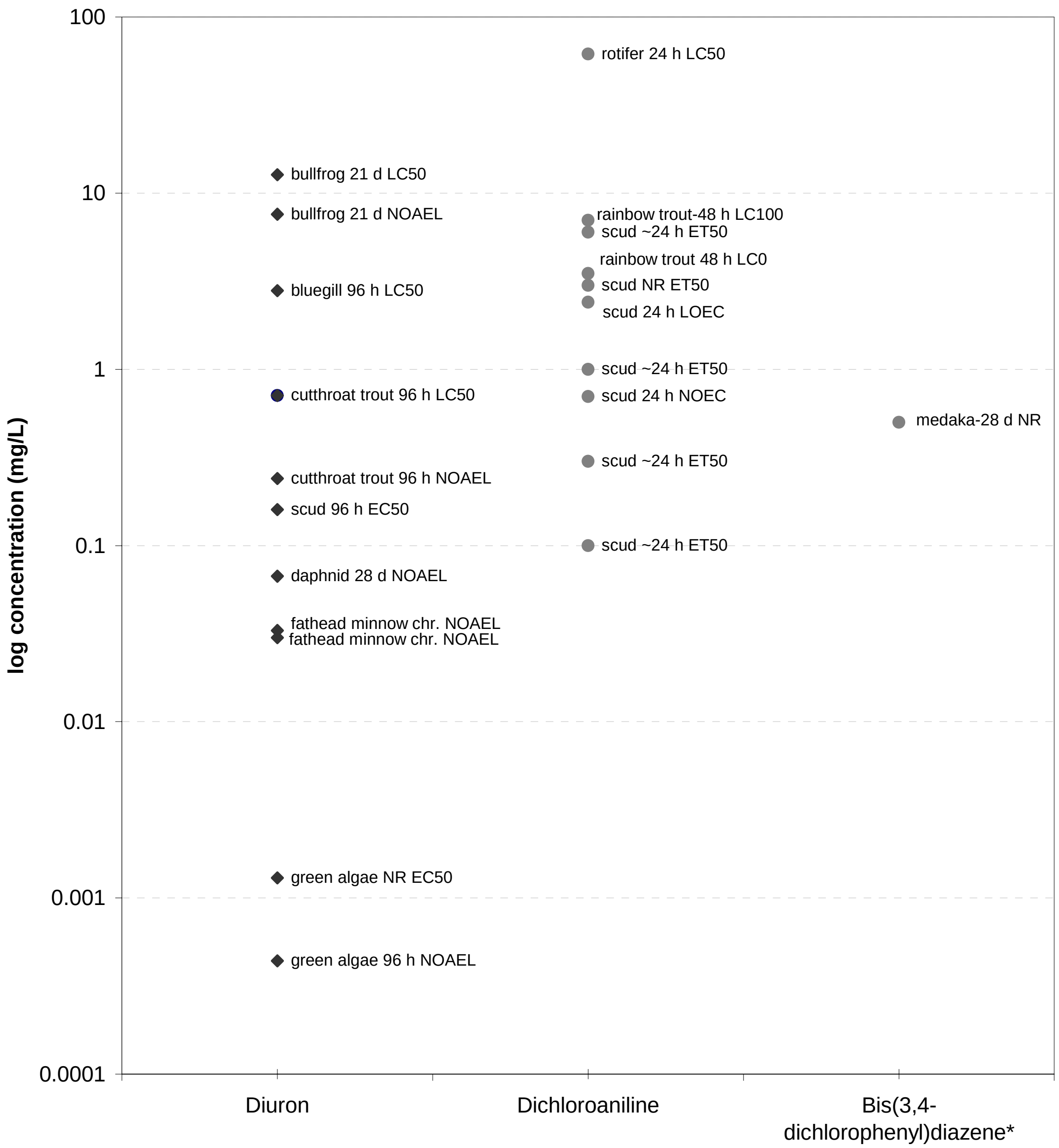
Label represents test organism, test duration, and endpoint.
Not all test organism names listed due to lack of space.
NR indicates duration or endpoint not reported.

FIGURE D-2
Aquatic Toxicity – Diquat Toxicity Reference Values and Degradate Toxicity Data



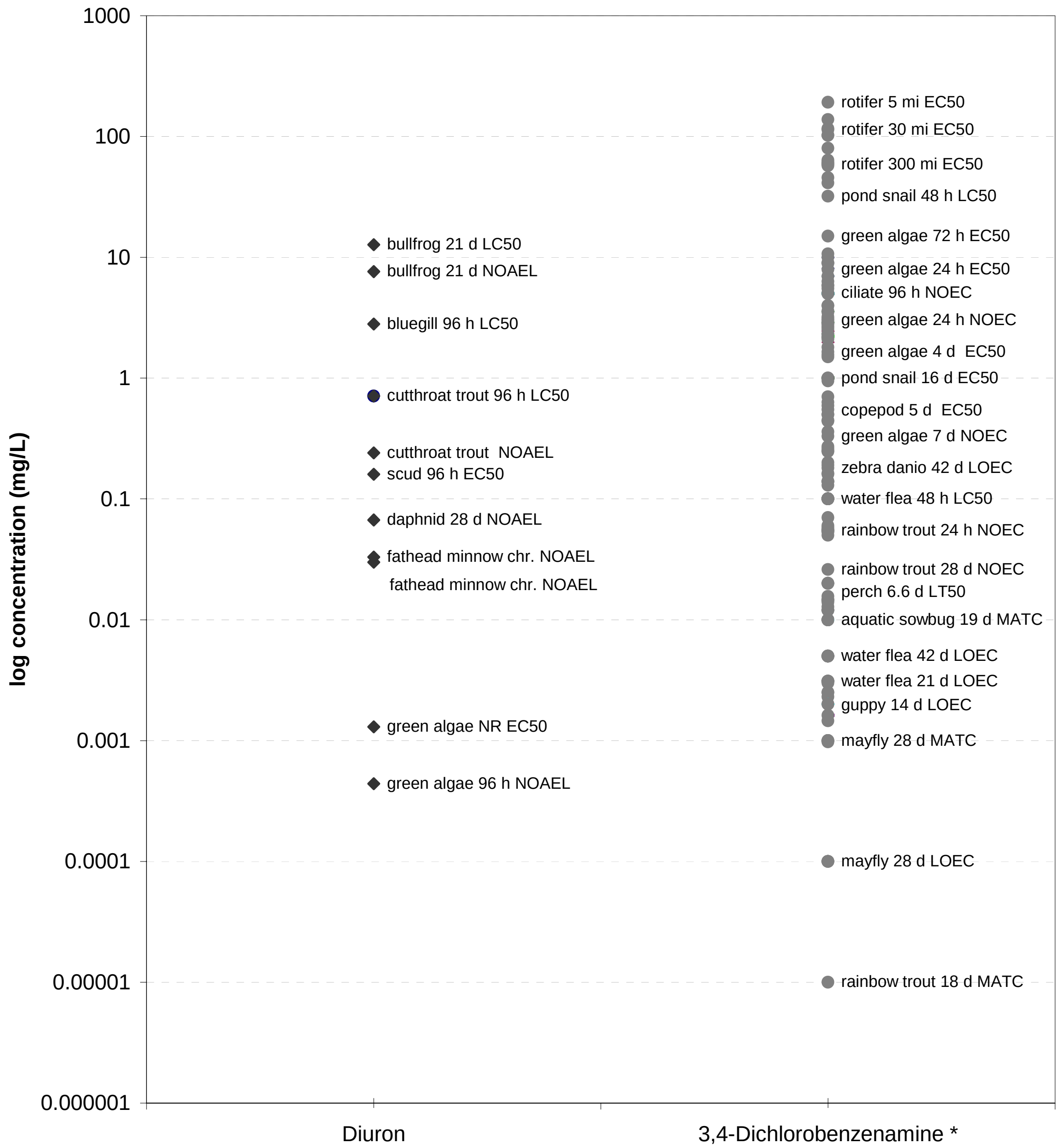
* Synonym for picolinic acid
Label represents test organism, test duration, and endpoint.
Not all test organism names listed due to lack of space.
NR indicates duration or endpoint not reported.

FIGURE D-3a
Aquatic Toxicity – Diuron Toxicity Reference Values and Degradate Toxicity Data



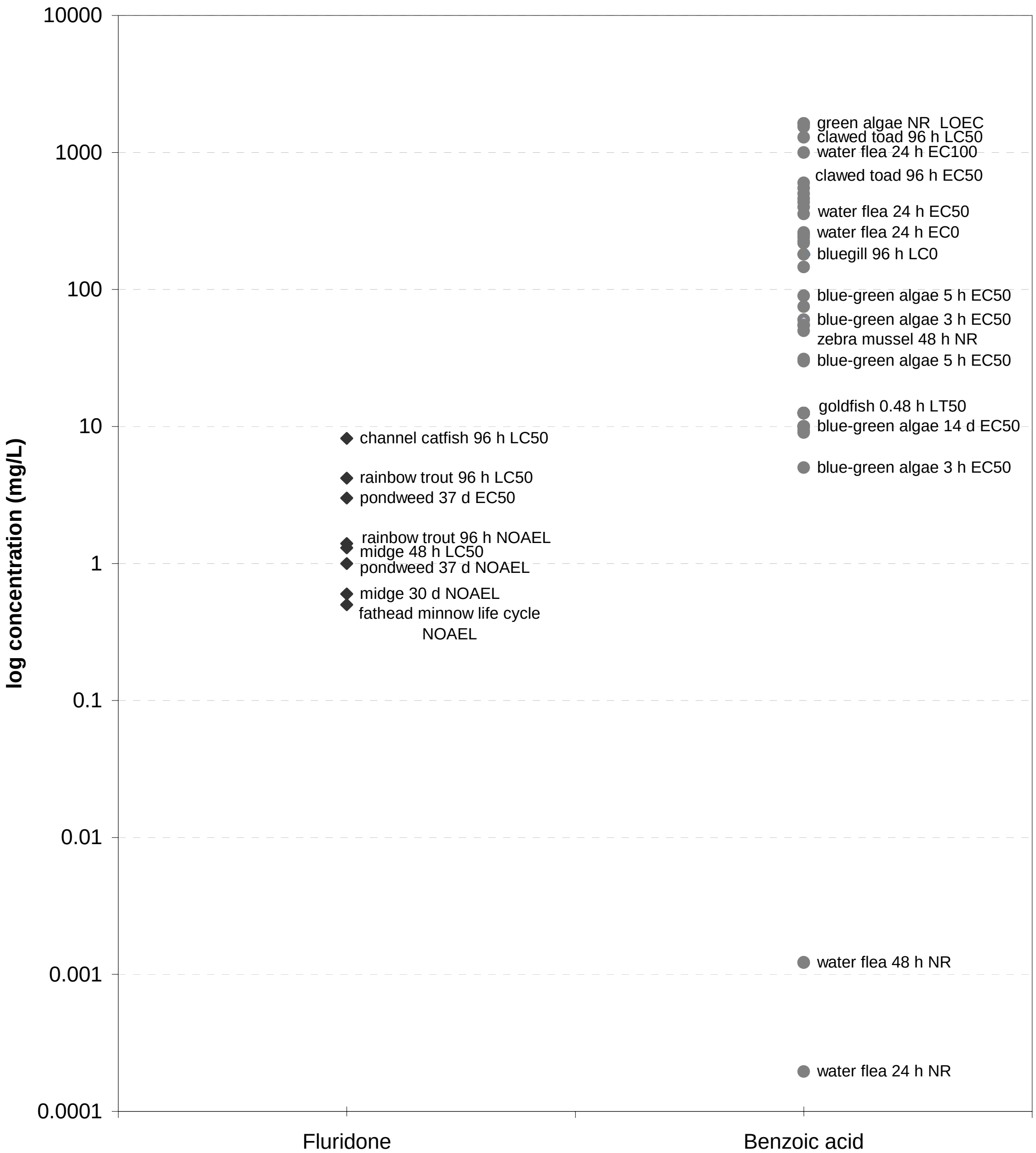
* Synonym for 3,3',4,4'-Tetrachloroazoxybenzene
Label represents test organism, test duration, and endpoint.
Not all test organism names listed due to lack of space.
NR indicates duration or endpoint not reported.

FIGURE D-3b
Aquatic Toxicity – Diuron Toxicity Reference Values and Degradate Toxicity Data



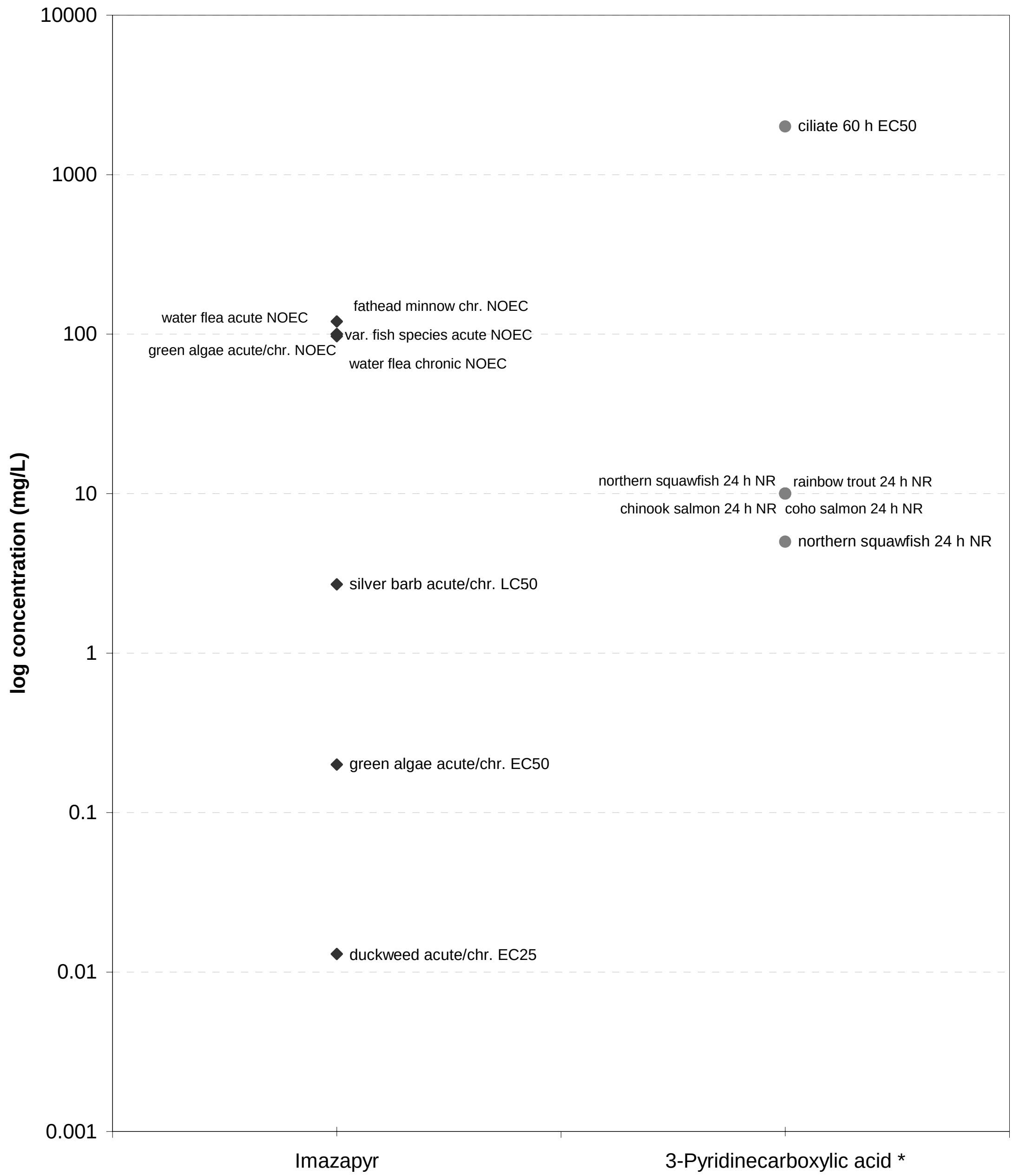
* Synonym for 3,4-dichloroaniline
Label represents test organism, test duration, and endpoint.
Not all test organism names listed due to lack of space.

FIGURE D-4
Aquatic Toxicity – Fluridone Toxicity Reference Values and Degradate Toxicity Data



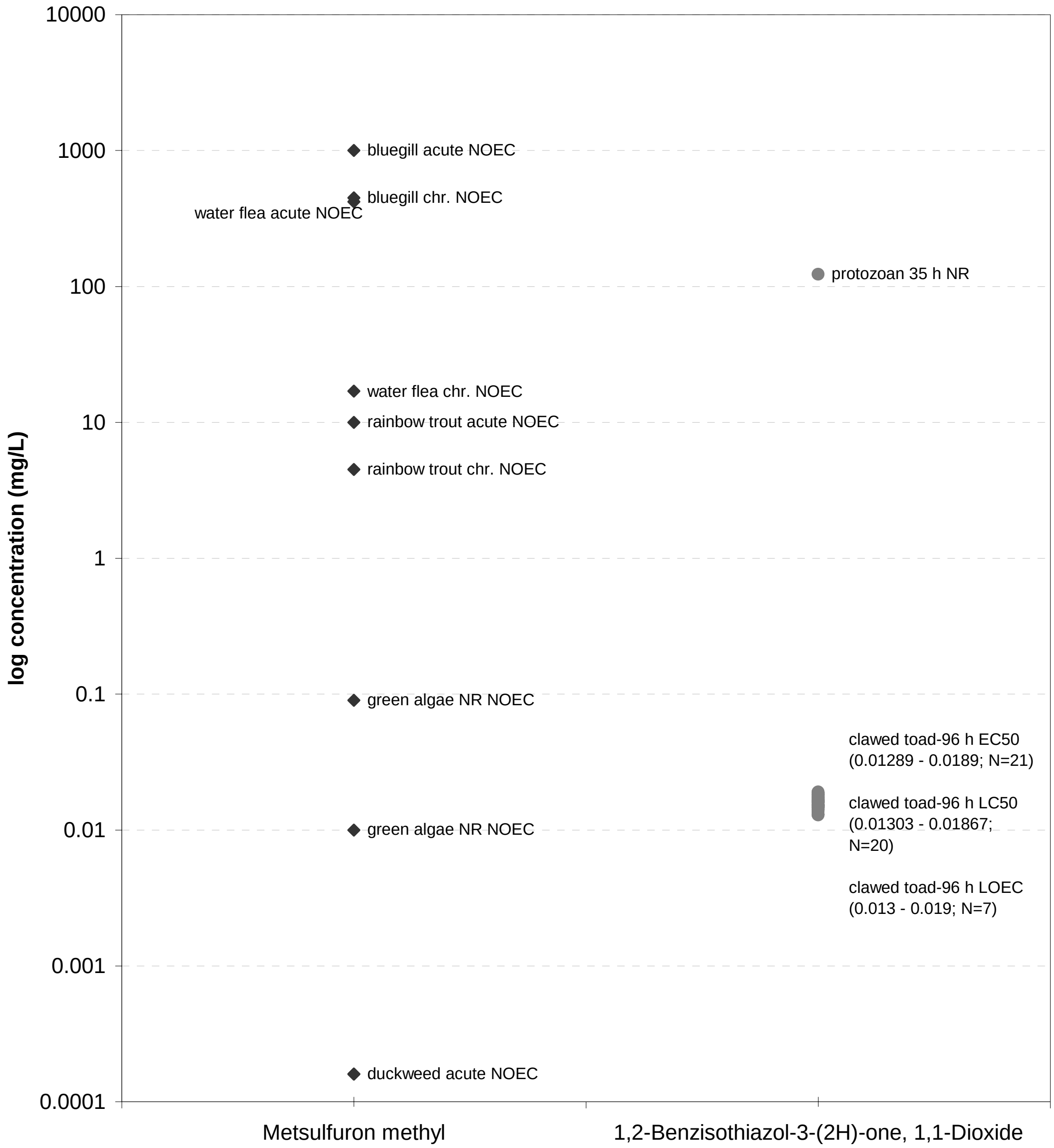
Label represents test organism, test duration, and endpoint.
Not all test organism names listed due to lack of space.

FIGURE D-5
Aquatic Toxicity – Imazapyr Toxicity Reference Values and Degradate Toxicity Data



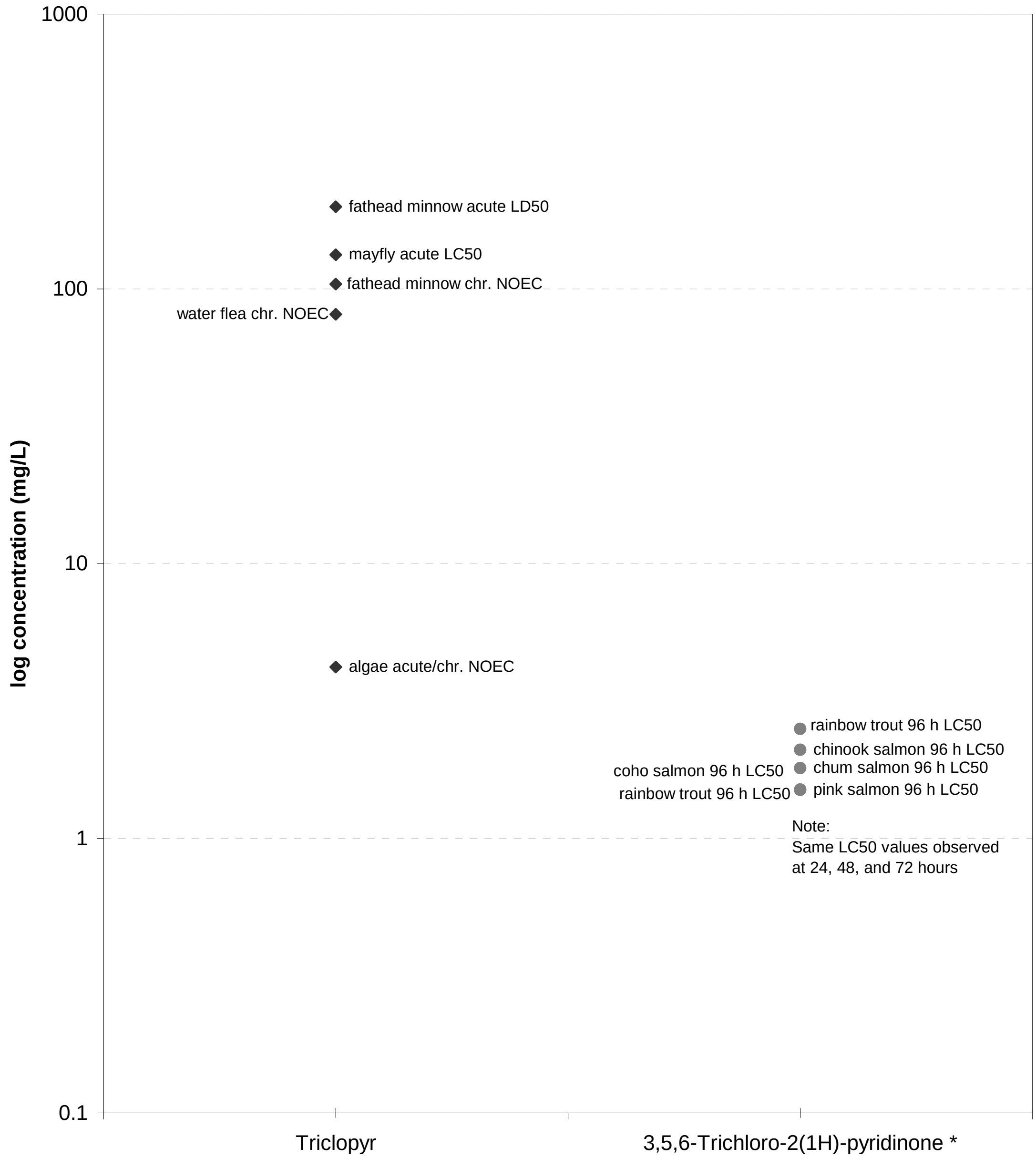
* Synonym for nicotinic acid
Label represents test organism, test duration, and endpoint.
Not all test organism names listed due to lack of space.
NR indicates duration or endpoint not reported.

FIGURE D-6
Aquatic Toxicity – Metsulfuron Methyl Toxicity Reference Values and Degradate Toxicity Data



Label represents test organism, test duration, and endpoint.
Not all test organism names listed due to lack of space.
NR indicates duration or endpoint not reported.

FIGURE D-7
Aquatic Toxicity – Triclopyr Toxicity Reference Values and Degradate Toxicity Data



* Synonym for 3,5,6-trichloro-2-pyridinol
Label represents test organism, test duration, and endpoint.
Not all test organism names listed due to lack of space.

TABLE D-5
Listings of Endocrine Disrupting Potential of BLM Herbicides

Herbicide	Benbrook List	Colborn List	Endocrine Disruptor Knowledge Base (EDKB)[1]	European Priority List[2]	Fluoride Action Net Pesticide Project[3]	Illinois EPA List	Keith List	National Institute for Environmental Studies	Pesticide Action Network List
2,4-D	***Yes***	***Yes***	Not an active estrogen receptor binder	***Category 2***	NL	***Probable***	***Yes***	***Listed***	***Suspected***
Bromacil	NL	NL	No Data	NL	NL	NL	NL	NL	NL
Chlorsulfuron	NL	NL	No Data	NL	NL	NL	NL	NL	NL
Clopyralid	NL	NL	No Data	NL	NL	NL	NL	NL	NL
Dicamba	NL	NL	No Data	NL	NL	NL	NL	NL	NL
Diflufenzopyr	NL	NL	No Data	NL	NL	NL	NL	NL	NL
Diquat	NL	NL	No Data	NL	NL	NL	NL	NL	NL
Diuron	NL	NL	No Data	***Category 2***	NL	NL	NL	NL	NL
Fluridone	NL	NL	No Data	NL	NL	NL	NL	NL	NL
Glyphosate	NL	NL	No Data	NL	NL	NL	NL	NL	NL
Hexazinone	NL	NL	No Data	NL	NL	NL	NL	NL	NL
Imazapic	NL	NL	No Data	NL	NL	NL	NL	NL	NL
Imazapyr	NL	NL	No Data	NL	NL	NL	NL	NL	NL
Metsulfuron methyl	NL	NL	No Data	NL	NL	NL	NL	NL	NL
Picloram	NL	NL	No Data	NL	NL	NL	NL	NL	NL
Sulfometuron methyl	NL	NL	No Data	NL	NL	NL	NL	NL	NL
Tebuthiuron	NL	NL	No Data	NL	NL	NL	NL	NL	NL
Triclopyr	NL	NL	No Data	NL	NL	NL	NL	NL	NL

TABLE D-5 (Cont.)
Listings of Endocrine Disrupting Potential of BLM Herbicides

[1] Endocrine Disruptor Knowledge Base (EDKB) is a database of endocrine disruption effects reported in scientific literature and is not a list of endocrine disruptors.

[2] Category 2 = Evidence of potential to cause endocrine disruption.

[3] Only lists fluorinated/fluoride pesticides.

NL = Not listed.

Benbrook List = **Benbrook, C.M. 1996.** Growing Doubt: A Primer on Pesticides Identified as Endocrine Disruptors and/or Reproductive Toxicants. National Campaign for Pesticide Policy Reform. Washington, D.C.

Colborn List = **Colborn, T., D. Dumanoski, and J.P. Myers. 2006. Our Stolen Future: A List of Endocrine-disrupting Compounds.** Accessed May 2, 2007. Available at: http://www.ourstolenfuture.org/Basics/chemlist.htm.

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Illinois EPA List = **Illinois EPA. 1997.** Endocrine Disruptors Strategy. (Table 1: Preliminary List of Chemicals Associated with Endocrine System Effects in Animals and Humans or In Vitro). Springfield, Illinois.

Keith List = **Keith, L.H. 1997.** Environmental Endocrine Disruptors: A Handbook of Property Data. Wiley Interscience. New York, New York.

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________. 2006d. Unpublished Study AMR 34-81. Wilmington, Delaware.

________. 2006e. Unpublished Study DuPont-1803. Wilmington, Delaware.

________. 2006f. Unpublished Study AMR 75-82. Wilmington, Delaware.

________. 2006g. Unpublished Study AMR 89-82. Wilmington, Delaware.

________. 2006h. Unpublished Study DuPont 1802. Wilmington, Delaware.

________. 2006i. Unpublished Study AMR 1001-87. Wilmington, Delaware.

________. 2006j. Unpublished Study DuPont-1811. Wilmington, Delaware.

________. 2006k. Unpublished Study DuPont-1815. Wilmington, Delaware.

________. 2006l. Unpublished Study AMR 34-81-A. Wilmington, Delaware.

________. 2006m. Unpublished Study AMR 1113-88. Wilmington, Delaware.

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